

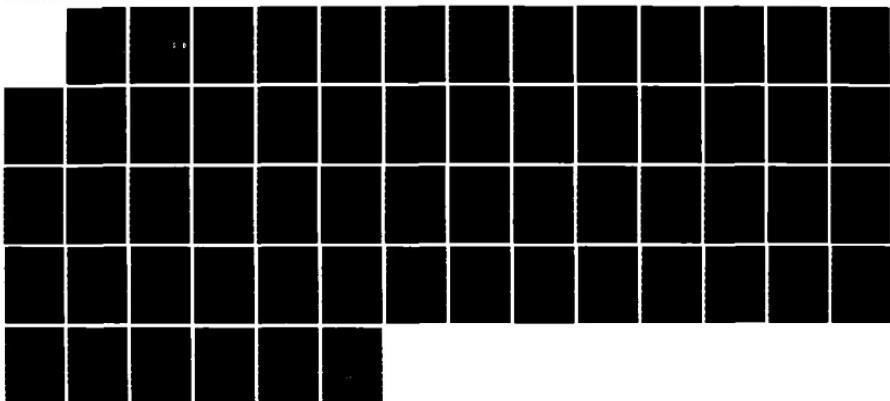
RD-A167 024

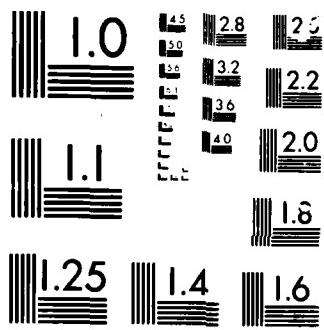
LOW INTENSITY CONFLICT COMBAT ATTRITION METHODOLOGY(U) 1/1  
COMBINED ARMS OPERATIONS RESEARCH ACTIVITY FORT  
LEAVENWORTH KS J M VUKSICH FEB 85 CAORA/TP-1-85

UNCLASSIFIED

F/G 5/9

NL





MICROCOPI

CHART

**AD-A167 024**

DTIC ACCESSION NUMBER

LEVEL

PHOTOGRAPH THIS SHEET

(1)

INVENTORY

**LOW INTENSITY CONFLICT  
COMBAT ATTRITION  
METHODOLOGY**

DOCUMENT IDENTIFICATION

**DISTRIBUTION STATEMENT A**

Approved for public release;  
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR	
NTIS	GRA&I
DTIC	TAB
UNANNOUNCED	
JUSTIFICATION	
BY	
DISTRIBUTION /	
AVAILABILITY CODES	
DIST	AVAIL AND/OR SPECIAL
A-1	

DISTRIBUTION STAMP



**DTIC ELECTED**  
MAY 12 1986

DATE ACCESSIONED

DATE RETURNED

REGISTERED OR CERTIFIED NO.

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-DDAC

Technical Paper TP 1-85  
February 1985

Methodology and Quality Assurance Directorate  
Combined Arms Operations Research Activity  
Fort Leavenworth, Kansas 66027

LOW INTENSITY CONFLICT COMBAT ATTRITION  
METHODOLOGY

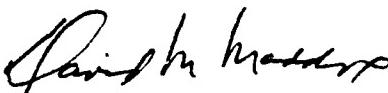
by  
Major John M. Vuksich

ACN 085741

Approved by:

  
H. Kent Pickett  
Acting Director  
Methodology & Quality  
Assurance Directorate

  
Reed E. Davis, Jr.  
Deputy, CAORA

  
David M. Maddox  
Brigadier General, USA  
Commander, CAORA

## REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>		1b RESTRICTIVE MARKINGS <b>NONE</b>			
2a SECURITY CLASSIFICATION AUTHORITY <b>N/A</b>		3 DISTRIBUTION/AVAILABILITY OF REPORT <b>Approved for public release; distribution is unlimited.</b>			
2b DECLASSIFICATION/DOWNGRADING SCHEDULE <b>N/A</b>					
4 PERFORMING ORGANIZATION REPORT NUMBER(S) <b>TP 1-85</b>		5 MONITORING ORGANIZATION REPORT NUMBER(S)			
6a NAME OF PERFORMING ORGANIZATION <b>USA Combined Arms Operations Research Activity (CAORA)</b>	6b OFFICE SYMBOL <i>(If applicable)</i> <b>ATOR-CAQ</b>	7a NAME OF MONITORING ORGANIZATION			
6c ADDRESS (City, State, and ZIP Code)  <b>Fort Leavenworth, Kansas 66027-5200</b>		7b ADDRESS (City, State, and ZIP Code)			
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL <i>(If applicable)</i>	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER			
8c. ADDRESS (City, State, and ZIP Code)  <b>Low Intensity Combat Attrition Methodology (U)</b>		10. SOURCE OF FUNDING NUMBERS			
		PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO
11. TITLE (Include Security Classification)					
12 PERSONAL AUTHOR(S) <b>Major John M. Vuksich</b>					
13a TYPE OF REPORT <b>Final</b>	13b TIME COVERED FROM _____ TO _____	14 DATE OF REPORT (Year, Month, Day) <b>84 January</b>		15 PAGE COUNT <b>57</b>	
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)  <b>Third World Mortars Firepower Model Development</b> <b>Host Nation Training Losses War Game</b> <b>Small Arms Attrition Methodology</b>			
19 ABSTRACT (Continue on reverse if necessary and identify by block number)					
This paper discussed the methodologies used to generate the Combat Results Tables (CRT) for the training simulation ABSALON as provided to USSOUTHCOM in October 1984. CRTs included address direct fire, ambush, small arms against landing helicopters, artillery/mortar, indirect fire and air-to-ground outcomes. A Markov pure death process is used to generate direct fire results and this process achieves Lanchester results. This Markov process is considered clever and might have application to other attrition methodologies.					
20 DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21 ABSTRACT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>			
22a NAME OF RESPONSIBLE INDIVIDUAL <b>MAJ John M. Vuksich</b>		22b TELEPHONE (Include Area Code) <b>AV 552/COMM (913)684-5511</b>		22c OFFICE SYMBOL <b>ATOR-CAQ</b>	

## TABLE OF CONTENTS

	Page
Title Page.....	i
Table of Contents.....	ii
Table of Figures.....	iii
Chapter 1. Introduction	
Background.....	1-1
Purpose.....	1-1
Scope.....	1-1
Classified Material.....	1-1
Chapter 2. Relative Combat Strength Table	
General.....	2-1
Methodology.....	2-1
Chapter 3. Ground Combat Table	
General.....	3-1
Methodology.....	3-1
Table Generation.....	3-3
Chapter 4. Ambush	
General.....	4-1
Methodology.....	4-1
Deficiencies.....	4-2
Chapter 5. Small Arms vs Landing Helicopters	
General.....	5-1
Methodology.....	5-1
Chapter 6. Direct Fire vs Vehicles and Mounted Personnel	
General.....	6-1
Methodology.....	6-1
Chapter 7. Mines and Boobytraps	
General.....	7-1
Methodology, Antipersonnel.....	7-1
Methodology, Antivehicular.....	7-1
Chapter 8. Sniper Table	
General.....	8-1
Methodology.....	8-1

## TABLE OF CONTENTS

### Chapter 9. Air Defense

General.....	9-1
Methodology, SA-7/Redeye.....	9-1
Methodology, Small Arms.....	9-1

### Chapter 10. Indirect Fire Support

General.....	10-1
Methodology.....	10-1

### Chapter 11. Air-to-Ground Table

General.....	11-1
Methodology.....	11-1

### Chapter 12. Air-to-Air Results

General.....	12-1
Methodology.....	12-1

FIGURES

	Page
2-1 Relative combat strength.....	2-2
3-1 Ground combat tables.....	3-2
3-2 Transition state space.....	3-4
3-3 State space conversion.....	3-5
3-4 Frequency of visits to ij.....	3-6
3-5 Percent losses.....	3-8
3-6 Combat model code.....	3-9
4-1 Ambush table.....	4-2
5-1 Direct fire vs landing helicopters.....	5-2
5-2 Vietnam combat data.....	5-3
5-3 Vietnam combat data.....	5-4
6-1 Direct fire vs vehicles and personnel.....	6-2
7-1 Mines and booby traps vs personnel.....	7-2
7-2 Mines vs vehicles and personnel.....	7-3
8-1 Sniper.....	8-2
9-1 SA-7/Redeye air defense.....	9-2
9-2 Small arms air defense.....	9-3
10-1 Indirect fire strength.....	10-2
10-2 Artillery damage squadron.....	10-3
10-3 Artillery damage, squad in jungle.....	10-4
10-4 Artillery damage, squad in urban.....	10-5
10-5 Artillery damage, platoon in open.....	10-6
10-6 Artillery damage, platoon in jungle.....	10-7
10-7 Artillery damage, platoon in urban.....	10-8
10-8 Artillery damage, company in open.....	10-9
10-9 Artillery damage, company in jungle.....	10-10
10-10 Artillery damage, company in urban.....	10-11
11-1 Air-to-ground, squad target.....	11-2
11-2 Air-to-ground, platoon target.....	11-3
11-3 Air-to-ground, company target.....	11-4
12-1 Air-to-air combat.....	12-2

## Chapter 1 Introduction

1-1. **Background.** In August of 1983 GEN Gorman, USCINCSO, contacted GEN Richardson, CDR, TRADOC, stating an urgent need for a low intensity conflict battalion level training simulation that could be translated into Spanish. Discussions between the Commander of TRADOC (CDR, TRADOC) and the Deputy Commandant of the Command and General Staff College (DCOMDT, CGSC) and the Director of BSD (DIR, BSD) resulted in a BSD DF dated 29 November 1983 that requested OTSD to develop that low intensity conflict game. On 19 January 1984 CDR, TRADOC tasked DCOMDT, CGSC to produce a battle simulation to train commanders and staff of Latin American forces in a low intensity conflict scenario using terrain typical of the region. As a result of these actions, CAORA became involved as the actual authors of the game ABSALON. After receiving the developmental test results, BG Maddox, the Commander of CAORA, directed that all the combat results tables be examined and regenerated if necessary. This action was to be completed in time for the 17 September 85 operational test. On 12 September, the Ground Combat Table was completed and incorporated into the operational testing. On 1 October MQA finished the regeneration of all the combat results tables and they were provided to Southcom on 12 October for final incorporation into the ABSALON game.

1-2. **Purpose.** This paper is an explanation of the methodology used by personnel in MQA to develop the combat results tables for the ABSALON game.

1-3. **Scope.** This paper will address all the combat results tables that are presented both in the basic ABSALON game and in the supplemental rules that accompany the game.

1-4. **Classified Material.** Substantial amounts of classified data were used in the preparation of the combat results tables. Since this paper will be unclassified and since the ABSALON game is unclassified, certain steps were taken to insure that there was no compromise of classified material. There were certain formats that we were required to follow. The analytical results that we developed did not neatly fit into the desired format. The translation of the analytical answers into the desired format provided a great degree of modification of the data; enough modification to insure that there is no possible compromise of classified data. As one reads through this paper, the methodology and the nature of the data that was used will be clearly presented. However, the actual numbers themselves will not be found in this paper.

## Chapter 2

### Relative Combat Strength Table

2-1. General. The ABSALON game is heavily dependent on firepower scores for different types of weapons. These firepower scores are used to compute the strength of each of the units in various types of engagements. Knowing that in a unit many different types of weapons are carried; some designed as anti personnel, some designed as anti tank, some designed as anti aircraft, etc., we had to develop a generic threat against which to base these firepower scores. Since ABSALON considers only a low intensity conflict, specifically guerrilla warfare, the most common target is believed to be people. The firepower scores shown in the final table (Figure 2-1) are a reflection of the weapons used against people.

2-2. The actual firepower score for any one weapon is not critical. What is critical is the relation of the firepower scores for each weapon among a group of weapons. To capture, for example, the correct relation of the value of an M16 versus the value of an M60 machine gun, the expected number of kills by each weapon in a one minute period was computed. This was done by taking the maximum sustained rate of fire for a weapon and multiplying that times the single shot kill probability for that weapon against a standing target at a range of 200 meters. The main deficiency is not with the generation of the firepower scores but rather with the nature of a firepower score itself. The main deficiency is the attempt to reduce a weapon to a single firepower score that is accurate for all situations.

RELATIVE COMBAT STRENGTH CHART

WEAPON TYPE	ABBREVIATION	COMBAT STRENGTH
PISTOL	P	1
SHOTGUN	S	1
RIFLE	R	2
GRENADE LAUNCHER	GL	2
LIGHT MACHINE GUN	LMG	7

Figure 2-1. Relative combat strength

### Chapter 3 Ground Combat Table

3.1. General. The ground combat table is the primary table used to determine the losses to red and blue in a jungle engagement. Figure 3.1 is the final table. To use the table, the strength of each force is computed by adding up the firepower scores of the weapons on each side. A ratio of red to blue is then computed. The letters of the column heads are coded ratios that go from 4<sup>+</sup>:1 at A to 1:7<sup>+</sup> at J. Column D is a ratio of 1:1. The next step is to choose a uniform random number between 1 and 99 inclusive. This number will designate the row to be entered. The table entry at the  $i$ th row and the  $j$ th column will display two percentages that reflect the red and blue losses at the end of the direct fire engagement. The problem of course was to generate the  $ij$  entries for the table.

3.2. Methodology. The most obvious fact to be recognized was that the battle began with a certain number of combatants on each side and transitions down to some point where the battle is over. At battle's end, a certain number of combatants remain. Since combat is a continuous process, the probability of two soldiers (side independent) being killed at the same exact instant is assumed to be zero. This assumption is consistent with theory of Markov chains upon which this methodology is based. Therefore the total state space of the battle is the product of the initial red combatants plus one times the initial blue combatants plus one. (To be completely correct, one should be subtracted from that product since a state of no blue and no red survivors cannot be achieved.) Each potential state is described by two pieces of information; the number of red surviving and the number of blue surviving at some time  $t$ .

The problem at this point was to capture the process that describes the transition from state to state. See figure 3.2. The process for both red and blue is strictly a death process. Therefore red and blue can transition only from higher to lower. Additionally, since two deaths cannot occur at the same instant, the process can transition only left or down to a lower value for either red or blue but never diagonally to a state with values lower for both sides.

A common assumption in combat modeling is that the interarrival times between deaths are distributed according to an exponential distribution. That assumption was made here. The exponential distribution is defined by a single parameter, the expected time until the next death. Additionally, the random variable which is the minimum of a group of random variables which are distributed exponentially according to parameters  $X_i$  has the property of also being distributed exponentially with a parameter  $X$  being equal to the sum of the  $X_i$ . This means that each soldier kills at some rate and the whole force kills at a rate which is the sum of the individual soldiers' rates.

The next step was to compute the killing rate for a red and blue soldier. To do this a typical ABSALON type of engagement was assumed to be a squad of blue "bumping" into a squad of red in the jungle. Neither side would have the

GROUND COMBAT TABLE  
(Table 2)

RANDOM NUMBER	STRENGTH RATIO LETTER									
	A	B	C	D	E	F	G	H	I	J
0 - 9	10/0	10/0	10/0	10/10	0/10	0/10	0/10	0/10	0/10	0/10
10 - 19	20/0	20/0	20/10	20/20	0/20	0/20	0/30	0/30	0/30	0/30
20 - 29	30/0	30/0	30/10	30/30	20/30	0/30	0/30	0/30	0/30	0/30
30 - 39	30/10	30/10	30/10	30/30	20/30	10/30	10/30	0/30	0/30	0/30
40 - 49	40/0	40/0	40/10	40/30	20/40	10/40	0/40	0/40	0/40	0/40
50 - 59	40/0	40/10	40/20	40/40	20/40	10/40	10/40	0/40	0/40	0/40
60 - 69	50/10	50/10	50/20	50/50	20/50	10/50	0/50	0/50	0/50	0/50
70 - 79	50/0	50/10	50/10	50/40	30/50	10/50	10/50	10/50	10/50	0/50
80 - 89	60/0	60/10	60/20	60/60	20/60	10/60	0/60	0/60	0/60	0/60
90 - 99	80/10	80/10	80/20	80/80	20/80	10/80	10/80	0/80	10/80	0/80

(ATTACKER PERCENTAGE LOSSES / DEFENDER PERCENTAGE LOSSES)

Figure 3-1. Ground combat table

advantage of the prepared positions of the attacker or the defender. The "typical" blue squad had one M60 machine gun, two M203 grenade launchers and six M16 rifles while the "typical" red squad had one M60 machine gun, one M203 grenade launcher and five M16 rifles. Another assumption was made that a soldier will engage only one opposing soldier in a one minute period and he will shoot at the maximum sustained rate of fire. With this assumption and the single shot kill probability, the expected number of kills by the red and blue forces for a one minute period can be computed. (Keeping in mind the expected value of a sum is the sum of the expected values.) The next step is to divide these rates by the number of red and blue soldiers. The result is that red kill at a rate of .375 blue per minute and blue kill at a rate of .353 red per minute. The assumption that soldiers fire at the maximum sustained rate is certainly questionable however ultimately this assumption falls out of the computation of the actual table entries. At this point, the readers attention is directed to figure 3-2.

Figure 3.2 provides all the necessary information to write a Monte Carlo simulation that starts at some initial force level and then transitions from state to state until a quitting condition is met. The quitting conditions are when either red or blue has zero soldiers left. Remember that the kill rate for each soldier has already been computed so given that when we are in state  $i_j$ , the transition rates out of that state are known. This is done by multiplying the blue (red) remaining by the blue (red) kill rate. We can thus select any desired starting force set and run the battle until one side is annihilated. In Figure 3.2, blue starts with 8 and red starts with 6.

Another bit of information available from figure 3.2 is the losses to either red or blue given the process is in some state  $i_j$ . By knowing the initial force strength, subtracting  $i$  and  $j$  yields the losses to each side. Figure 3.2 can be shuffled into a new form shown in figure 3.3 where the column headings reflect blue losses and the row headings reflect red losses. So, given state  $a_{ij}$ , the losses to red and blue can readily be determined. Note that the transition from figure 3.3 back to figure 3.2 cannot be made since information about the initial force strengths has been lost. Next, the value that  $a_{ij}$  is assigned needs to be examined.

Returning to thoughts of the Monte Carlo simulation, we choose a red and blue initial strength ( $B, R$ ) and the number of cycles desired. At the beginning of each cycle, the process will be in state  $B, R$  and then the simulation will follow some path through the state space to one of the many quitting conditions. If  $C$  cycles are chosen for the simulation, then the process will be in state  $B, R$  exactly  $C$  times since each cycle starts there. Assign a value of  $C$  to  $a_{00}$ . Now run  $C$  cycles of the simulation, record the number of visits by the process in  $C$  cycles to each state and record that value as  $a_{ij}$ . Figure 3.4 reflects that count for 50 cycles with blue initial at 8 and red initial at 6.

TRANSITION STATE SPACE FOR BLUE FORCE OF 3  
AND A RED FORCE OF 6

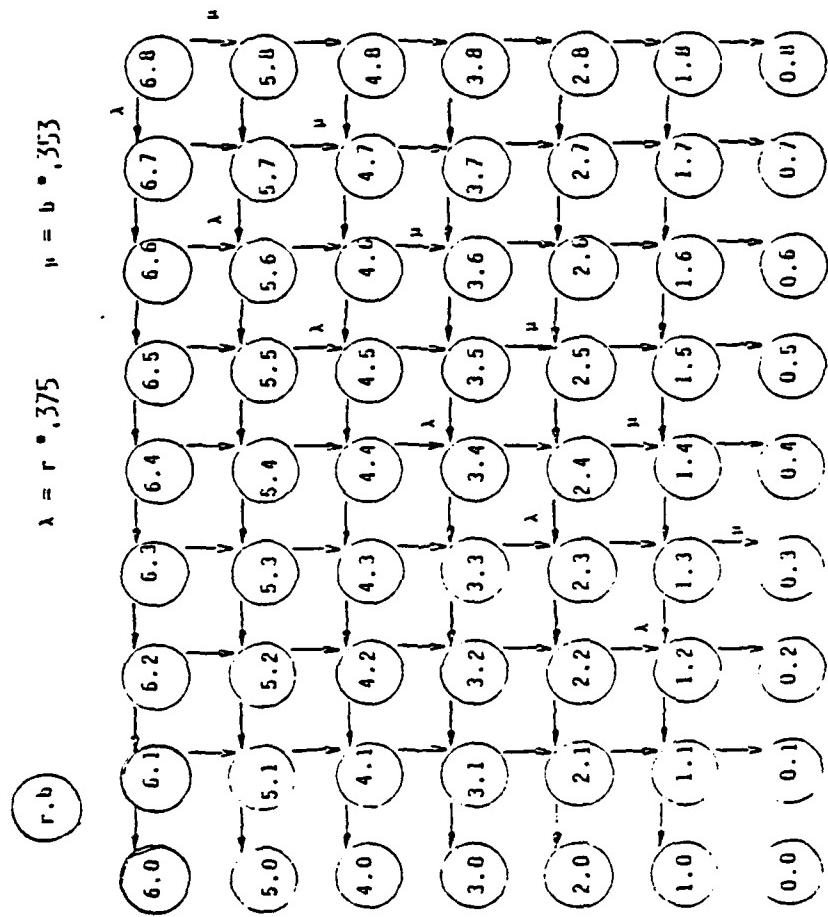


Figure 3-2. Transition state space

CONVERSION OF STATE SPACE INTO A  
RED AND BLUE LOSS DIAGRAM

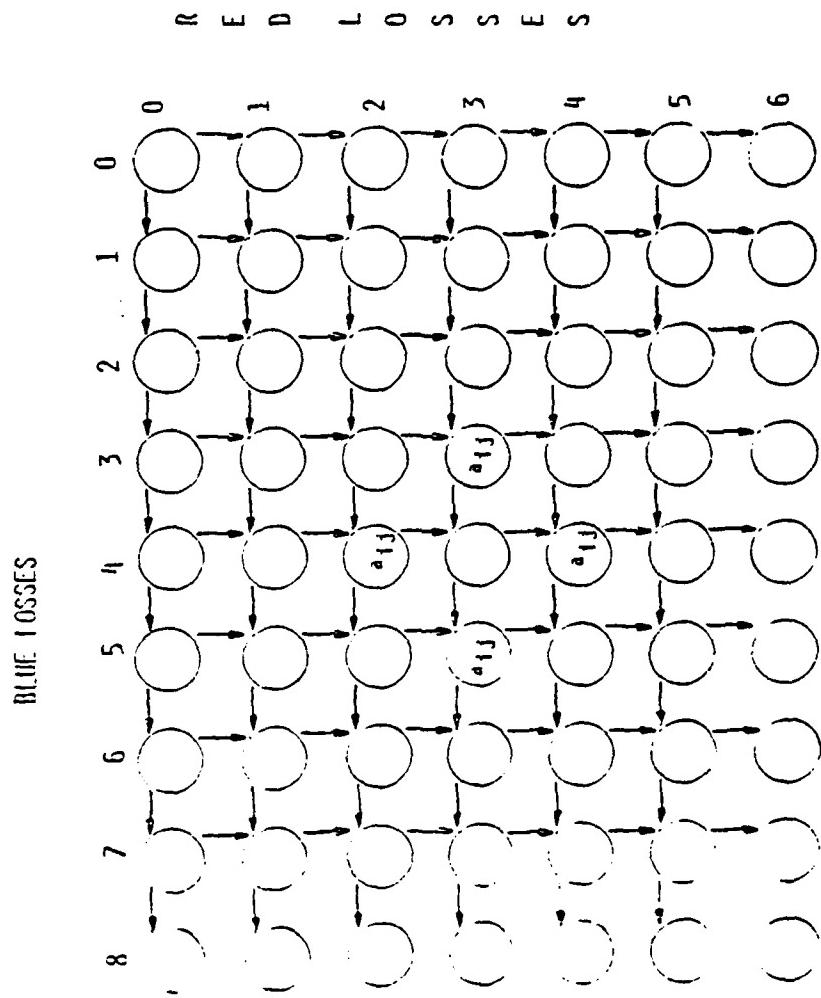


Figure 3-3. State space conversion

FREQUENCY OF VISITS TO STATE  $i,j$   
IN 50 TRIAL BATTLES

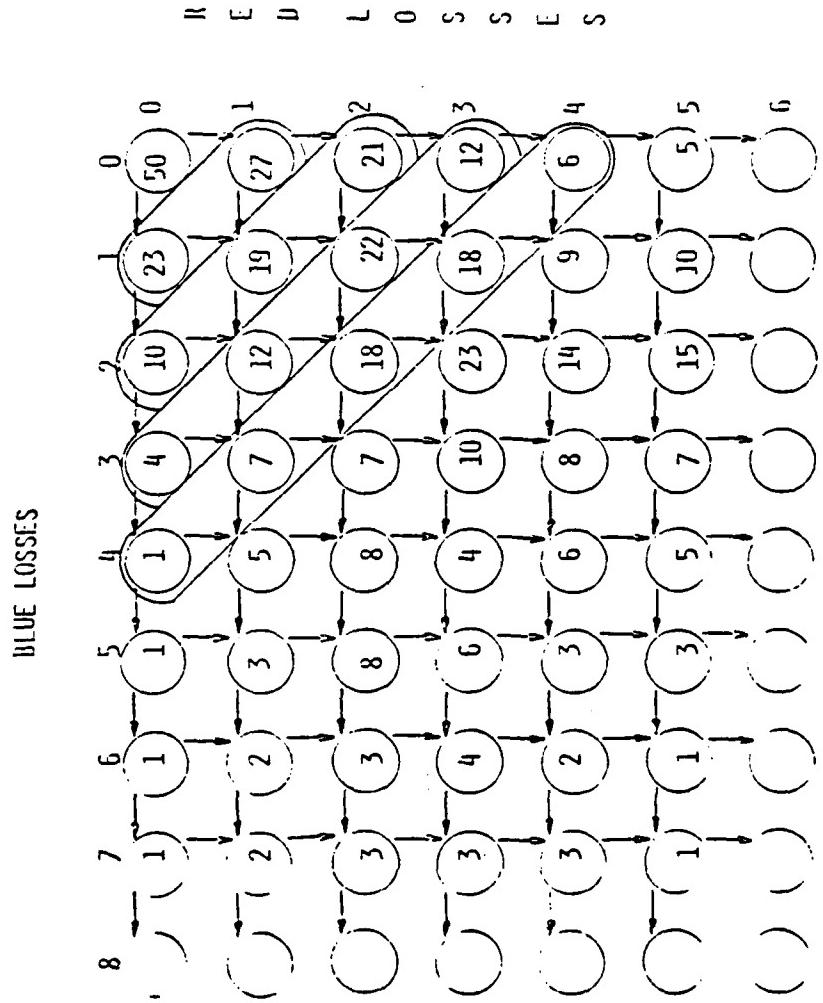


Figure 3-4. Frequency of visits to  $i,j$

Recall now the assumption that soldiers fire at the maximum sustained rate of the weapon. Figure 3.4 records the number of visits to a state and not the total time in that state. The rate of fire assumption has fallen out, i.e., if the rate of fire increases, the process would occur more rapidly but the number of visits to that state would remain the same. Since the quitting condition is the surviving force level as opposed to a "time in battle", the assumption of soldiers firing of maximum sustained rate is not a driving fact in the calculations.

On figure 3.4, diagonal ellipses have been drawn. Note that the sum of the entries in each ellipse equals the number of cycles. Each cycle begins at state B, R and then the process proceeds through each diagonal ellipse being in that ellipse exactly once per cycle. Each diagonal ellipse has an expected number of red losses and an expected number of blue losses because for each  $a_{ij}$  in that diagonal there is an associated red and blue loss and, for each  $a_{ij}$ , there is a probability of being in that state with those respective losses. The probability, given the process is in a certain diagonal, that the process is in the state  $a_{ij}$  is given by  $a_{ij}$  divided by C.

Since each cycle passes through each diagonal exactly once, then, given initial forces, data points of expected red and blue losses are generated and a graph of red losses against blue losses can be made that reflects the expected strength of each side at any point in the battle. These plots achieve results which are exactly Lanchester according to the square law. The actual program used to generate the data points is Figure 3.6.

**3.3 Table Generation.** A tool was now available to show the results of a battle for given initial red and blue force strengths at a desired point in the battle until annihilation of one side occurred. A weakness with Lanchester is that there is no battle termination criteria other than annihilation. The following assumptions were made about the quitting condition of the battle. First, the decision to terminate the engagement will be made by the smaller force. The second assumption was that the battle terminated when the smaller force was reduced to a mean of 65% of the original force and that the smaller force loss was distributed truncated normal about that mean.

In figure 3.5, the losses of the smaller forces are chosen at 10% intervals and the corresponding larger force losses are paired with them. Note also that many force ratios are presented. The next step is to then assign a probability that the smaller force will suffer a given 10 percentage loss according to the truncated normal distribution. Note this is done with a sequence of numbers that run from 1 to 99.

Finally, figure 3.5 was converted into the actual ground combat table shown at figure 3.1. This was required because the format of the table used in the game dictated that the random numbers be grouped in sets of 10. Red and blue losses were then grouped to reflect the expected results in 10% chance blocks by modifying the 10% loss groupings that were started with.

PERCENT BLUE LOSS/PERCENT RED LOST

RANDOM NUMBER	FORCE RATIO	PERCENT BLUE LOSS/PERCENT RED LOST							
		1:4	1:3	1:2	1:1	2:1	3:1	4:1	5:1
90-100	10/1	10/2	10/3	10/8	6/10	2/10	1/10	1/10	1/10
75-89	20/2	20/4	20/7	20/17	10/20	4/20	2/20	1/20	1/20
56-74	30/2	30/5	30/10	30/25	14/30	6/30	3/30	2/30	1/30
37-55	40/3	40/6	40/12	40/36	17/40	7/40	3/40	3/40	2/40
22-36	50/4	50/7	50/15	50/46	19/50	8/50	4/50	3/50	2/50
13-21	60/4	60/7	60/17	60/56	20/60	9/60	5/60	3/60	2/60
7-12	70/5	70/8	70/14	70/66	22/70	10/70	5/70	4/70	2/70
4-6	80/5	80/8	80/20	80/76	23/80	11/80	6/80	4/80	3/80
2-3	90/5	90/9	90/22	90/86	24/90	12/90	7/90	4/90	3/90
1-1	100/6	100/7	100/24	100/96	25/100	13/100	7/100	5/100	3/100

Figure 3-5. Percent losses

```

10      OPTION BASE 1
11      PRINTER IS 1
20      INTEGER I,J,A,B,Imin,M,N,Rk,Bk
30      REAL Ratei,Ratej,Timkili,Timkilj
40      DIM Tim(100,100)
50      DIM Cnt(100,100)
60      DIM Exprk(100)
70      DIM E:bk(100)
80      DIM Exprk(100)
90      DIM Epbk(100)
100     INPUT "INPUT BLUE FORCE",I
110     INPUT "INPUT RED FORCE",J
120     INPUT "INPUT CYCLES",C
130     REDIM Tim(I,J)
140     Tottim=0
150     MAT Tim= (0)
160     FOR A=1 TO C
170         I1=I
180         J1=J
190         REDIM Cnt(I1,J1)
200         WHILE (I1>0) AND (J1>0)
210             Cnt(I1,J1)=Cnt(I1,J1)+1
220             Ratei=J1*.356
230             Ratej=I1*.347
240             Timkili=(-1/Ratei)*LOG(1-RND)
250             Timkilj=(-1/Ratej)*LOG(1-RND)
260             IF (Timkili>Timkilj) THEN
270                 Tim(I1,J1)=Timkilj+Tim(I1,J1)
280                 J1=J1-1
290             ELSE
300                 Tim(I1,J1)=Timkili+Tim(I1,J1)
310                 I1=I1-1
320             END IF
330             END WHILE
340             NEXT A
350             FOR A=1 TO I
360                 FOR B=1 TO J
370                     Tim(A,B)=Tim(A,B)/C
380                     Tottim=Tottim+Tim(A,B)
390                 NEXT B
400             NEXT A
410             FOR A=1 TO I
420                 FOR B=1 TO J
430                     PRINTER IS 702
440                     PRINT "TIM(";A;"";B;")=";Tim(A,B)
450                     Tim(A,B)=Tim(A,B)/Tottim
460                     PRINT "PERCENT(";A;"";B;")=";Tim(A,B)
470                     PRINT "TOTAL VISITS(";A;"";B;")=";Cnt(A,B)
480                 NEXT B
490             NEXT A

```

Figure 3-6. Combat model code

```

401      PRINT "TOTAL TIME=";Tottim
402      PRINT "BLUE FORCE =";I
403      PRINT "RED FORCE =";J
404      Imin=I
405      IF J<Imin THEN Imin=J
406      REDIM Exrk(Imin)
407      REDIM Exbk(Imin)
408      REDIM Exprk(Imin)
409      REDIM Expbk(Imin)
410      FOR A=1 TO Imin
411          M=I
412          N=J-A+1
413          MAT Exrk=(0)
414          MAT Exbk=(0)   ---
415          FOR B=1 TO A
416              Rk=A-B
417              Bk=B-1
418              Exrk(A)=Exrk(A)+Cnt(M,N)*Rk/C
419              Exbk(A)=Exbk(A)+Cnt(M,N)*Bk/C
420              M=M-1
421              N=N+1
422              NEXT B
423              Exprk(A)=Exrk(A)*100/J
424              Expbk(A)=Exbk(A)*100/I
425              PRINT "AT STAGE";A
426              PRINT "EXPECTED RED KILLED =";Exrk(A);"OR";Exprk(A);"%"
427              PRINT "EXPECTED BLUE KILLED =";Exbk(A);"OR";Expbk(A);"%"
428              NEXT A .
429              PRINTER IS 1
430              END

```

Figure 3-6 (cont). Combat model code

## Chapter 4 Ambush

4.1. General. The ambush table, figure 4.1, provides red and blue losses for an ambush situation. Its use follows exactly the same procedures as the ground combat table. See para 3.1 for a complete explanation.

4.2. Methodology. The methodology used in the generation of the ambush table draws heavily on the results of the ground combat table.

FM 7-8, The Infantry Platoon and Squad, provides the doctrinal foundation for the conduct of an ambush at the platoon and squad level. This organizational level is consistent with the design resolution of the training simulation. In an ambush, the ambushing force selects a position from which they can provide fire into a preselected area called the kill zone. FM 7-8 defines the kill zone as "that part of the ambush site where fire is concentrated to isolate, trap and destroy the target." Weapons are integrated into a fire plan to optimize the ambushing force's destructive capabilities. When an enemy force enters the kill zone, the ambush is initiated violently and simultaneously to "achieve surprise as well as the destruction of the target." FM 7-8 flatly states that "surprise must be achieved, else the attack is not an ambush." All of the enemy force may be in the kill zone or only a portion of the enemy force may be in the kill zone. FM 7-8 states that "the size of the kill zone is limited by the area the assault and security elements can cover with a great volume of fire."

Let us restate U.S. doctrine learned to this point that will be used later as building blocks for the methodology:

- a. If an ambushing force does not achieve surprise, then the engagement is an attack, not an ambush. Hence, for an ambush not properly executed, the direct fire combat results table should be used.
- b. The target are those enemy assets exclusively within the kill zone and the target should be destroyed.
- c. The size of the kill zone is a variable.

At this point three assumptions were made:

- a. That portion of the enemy force in the kill zone would be destroyed; the results called for in U.S. doctrine. No known analysis supports or rejects this assumption.
- b. Since the kill zone size is a variable, some methodology is required that captures that variability. Further, the simulation architecture constrained the author to "force ratio" as the sole entry variable into the ambush combat results table. This, in turn, meant that the methodology could use only that information available in the statistic "force ratio."

AMBUSH TABLE

(Table 4)

STRENGTH RATIO LETTER

RANDOM NUMBER	A	B	C	D - J
0 - 19	0/20	0/30	0/50	0/60
20 - 39	10/30	10/40	10/60	0/80
40 - 59	20/30	20/40	20/60	0/100
60 - 79	30/30	30/40	30/70	0/100
80 - 99	60/30	60/50	60/90	20/100

(ATTACKER/DEFENDER % CASUALTIES)

Figure 4-1. Ambush table

Hence, it was assumed that the size of the kill zone would be large enough to contain the target force, and, the size of target force would be equal to the size of the ambushing force. Again, no known analysis supports or rejects this assumption.

c. Any portion of the ambushed force not in the kill zone would then engage the ambushing force after the ambushing force destroyed the target force. The results of that battle would be generated using the methodology in Chapter 3.

In the ambush process, two things happen. First, everyone in the kill zone is killed. Second, the ambushing force has consumed the benefits of an ambush. At this point, there are two forces on the ground, the ambushing force and the ambushed unit less those killed in the ambush (an assumed amount equal to the ambushing force). At this point, with these force levels, the battle degenerates into the ground combat situation discussed in chapter 3.

One difference between the ambush and the ground combat is that the ambushing force will have planned escape routes out of the area and they will generally not want to stay and fight. As such the quitting condition for the battle is a random variable (the percent remaining of the ambushing force) distributed truncated normal around a mean of 85%.

Summarizing the algorithm:

- a. Compute the strength of the ambush force and the ambushed unit.
- b. Kill an amount of the ambushed unit equal to the ambush force.
- c. Run the simulation in chapter 3 with the remaining forces as the "initial" force.
- d. Quit when the ambush force strength drops to 85%.

4.3. Deficiencies. This methodology degenerates any time the ambush force is equal to or larger than the ambushed unit. The methodology demands 100% kill all the time. In the spirit of providing some variability in the game, the entries in the last column of figure 4.1 have been subjectively modified away from the 0%/100% loss demanded by the methodology.

## Chapter 5

### Small Arms vs Landing Helicopters

5.1. General. The small arms vs landing helicopters table is used to determine blue losses of helicopters and personnel when blue conducts a combat assault into a landing zone covered by red small arms fire. To use the table, figure 5.1, the combat strength of the red unit is determined. Next, that strength is divided by the number of helicopters in the serial. That provides a combat strength figure to be applied to each helicopter in that serial (this designates a column in the table). Next a uniform random number [1, 99] is drawn. This draw will designate a table row. The entry in the table identified with the  $i$ th row and the  $j$ th column provides two bits of information, helicopter damage and people damage (given as a percentage). The process is repeated for each helicopter in the serial. This methodology assumes that all helicopters in a given serial arrive at the same instant in time.

5.2. Methodology. The current political and military situation in LATAM reflects somewhat the U.S. experience in Vietnam. This is particularly true for the helicopters in use, the UH1 series, and the main threat to those helicopters, small arms. As such, data from Vietnam on damage to UH1 series helicopters hit by small arms fire while making a heliborne assault were used as the basis for the damage inflicted on the helicopters and, to some degree, personnel damage.

Figures 5.2 and 5.3 are copies of the information on file at the Combat Data Information Center at Wright Patterson Air Force Base. The following data are extracted.

1. Given a helicopter is hit, the probability that the aircraft is destroyed is 0.05. The probability the aircraft must do something it does not want to do (force landing, mission abort, precautionary landing, etc.) is 0.20. The probability that the aircraft completes its mission without interruption is 0.75.

2. The damage from round to round is independent. This is to say that the effect of say 5 small arms hits is not additive but that each of the 5 bullets is a separate draw against the damage distribution inflicted against the helicopter.

The methodology used was to first determine the probability that a helicopter was hit at least once given that  $n$  rounds were fired at the helicopter. And then, given the helicopter was hit, to apply a level of damage against the helicopter according to the data out of Vietnam. The probability of hitting a helicopter is a straight forward calculation from DARCOM-P 7806-101. The equation is:

$$P(\text{at least one hit}) = 1 - \exp \frac{-nA}{A + 2 S^2}$$

where:

A = area of the helicopter ( $\text{meters}^2$ )

n = number of rounds fired

S = range ( $\text{km}$ )  $\times \sigma$

$\sigma$  = root mean square sum of all the aim errors ( $\text{mils}$ )

DIRECT FIRE VS. LANDING HELICOPTERS  
 (Table 9)

		ATTACKING UNIT COMBAT STRENGTH								
RANDOM NUMBER	0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45+
0 - 59	--	--	--	--	--	--	--	--	--	--
60 - 69	--	--	--	--	--	--	--	--	--	--/10
70 - 79	--	--	H	H	H	H	H	H/10	H/10	H/10
80 - 89	--	H	H/10	D/40						
90 - 99	H	H	D/10	D/10	D/10	D/10	D/10	D/40	D/40	D/40

\*NUMBER = PERCENTAGE HELICOPTER PASSENGER AND CREW CASUALTIES

- - - - NO DAMAGE TO TARGET HELICOPTER
- H HELICOPTER MOBILITY DAMAGE
- D HELICOPTER DESTROYED

Figure 5-1. Direct fire vs. landing helicopters

<u>DAMAGES</u>		<u>LOSSES</u>	<u>TOTAL</u>
<u># of Aircraft</u>	<u># of Aircraft</u>	<u># of Aircraft</u>	
565	Total sample size UH-1, SA/AW, pick-up zone, Landing zone, ops area	29	594
<hr/>			
<u>DAMAGES</u>		<u>LOSSES</u>	
<u># HITS</u>		<u># of Aircraft</u>	
<u># of Hits</u>	<u># of Aircraft</u>	<u># of Aircraft</u>	
01	298	14	
02	106	2	
03	56	2	
04	26	-	
05	20	1	
06	19	-	
07	10	-	
08	13	-	
09	1	-	
10	4	-	
11	1	-	
12	2	-	
15	2	-	
20	1	-	
25	-	1	
26	1	-	
33	-	1	
99 (Unknown)	5	3	
<hr/>			
565		29	

Figure 5-2. Vietnam combat data

OPERATIONS IMPACT - the immediate impact on the flight capability of the aircraft as a result of the incident.

<u>OPS IMPACT</u>	<u>DAMAGES</u>	<u>LOSSES</u>
	<u># of Aircraft</u>	<u># of Aircraft</u>
CONTINUED FLIGHT	494	-
EMERGENCY LANDING	6	2
FORCED LANDING	45	11
PRECAUTIONARY LANDING	15	-
UNKNOWN	5	5
CRASH	-	11
	565	29    TOTAL # of Aircraft

MISSION IMPACT - the effect of the incident on the mission capability of aircraft.

<u>MISSION IMPACT</u>	<u>DAMAGES</u>	<u>LOSSES</u>
	<u># of Aircraft</u>	<u># of Aircraft</u>
COMPLETED	456	-
ABORDED	48	-
MODIFIED	38	-
TERMINATED	15	29
UNKNOWN	9	-
	565	29    TOTAL # of Aircraft

Figure 5-3. Vietnam combat data

For the aim error components (ballistic, human and aimpoint) AMSAA provided data. The average range of engagement was selected at 300 meters. The fully exposed side of a UH1 is approximately 20 square meters.

At this point, some assumptions had to be made to determine the number of rounds fired at the helicopter. To do this the firepower score in the column heading must be reduced to numbers of weapon types and then a statement about the number of rounds fired by each type weapon needed to be made. Recall the typical "red" squad from chapter 3. It has one M60 machine gun, one M203 grenade launcher (shot as a rifle at a flying helicopter) and five M16 rifles. As the weapons were grouped to generate a typical firepower score in each column, the ratio of one machine gun to 6 rifles was roughly maintained. At this point, the assumption made was that each M16/M203 would fire 12 rounds and the M60 would fire 10 bursts of 5 rounds. This assumption is based upon the guess that the helicopter would be exposed for one minute and that the maximum sustained rate of fire for the weapons would be used. By using these assumptions, each column heading firepower score has an associated number of bullets fired.

To compute the personnel casualties, the area in the door of the helicopter occupied by a soldier is approximately .588 square meters. In the equation above, if A becomes the area of the soldiers and n equals one, then a single shot kill probability against a soldier inside the helicopter is given. Since each shot is assumed to be an independent event, the expected number of rounds to pass through the troop compartment is  $n \cdot p$ . In all cases, fewer than 1 round was expected to pass through the troop compartment, so no more than 1 soldier can become a casualty. Next, compute the probability that at least one round of n fired would enter the troop compartment. The one possible casualty was then put into the table according to that probability.

This methodology was not used for helicopters that were destroyed. In Vietnam, the average number of casualties in a crash was either 4 or 1 depending on whether the helicopter burned or did not burn. A crashed helicopter burned 43% of the time and did not burn 57% of the time. Therefore, given that the table entry showed "helicopter destroyed" then 40% of the time, 4 casualties were assigned and 60% of the time 1 casualty was assigned.

The results for personnel damage in this table line up closely to the Vietnam data.

## Chapter 6

### Direct Fire vs Vehicles and Mounted Personnel

6.1. General. The use and format of the Direct Fire vs Vehicles and Mounted Personnel, Figure 6.1, follows very closely the format of the Direct Fire vs Landing Helicopter. Again, the red combat strength is computed then divided by the number of trucks. That remaining score will identify the table column to be used. Next, a uniform random number [1, 99] is drawn to determine the table row. The entry at the  $i$ th row and the  $j$ th column will provide two bits of data: damage to the vehicle and damage to personnel. This procedure is applied against each truck one at a time.

6.2. Methodology. As stated in chapter 2, there are deficiencies with the firepower score techniques. Since the primary LATAM engagement is personnel vs personnel, the addition of anti-tank weapons into the firepower score would be inappropriate. It is equally inappropriate to say then that anti-tank weapons (LAW, RPG, 90mm RR, etc.) are not available in the force. Recall from chapter 5 how the firepower score column headings were assigned a certain number of M16 rifles and M60 machine guns. This table has the same firepower score column heading and as such the same M16/M60 assignment is used. OTSD personnel described the number of LAW's and 90mm recoilless rifles that were associated with each M16/M60 assignment. Each LAW or 90mm could fire one time in the truck engagement. So in essence, the effectiveness of anti-tank weapons is built into the table following a ratio of what would reasonably be expected for that weapon against the M16/M60 mix.

The next assumption made was that the anti-tank weapons would be fired at the truck and the personnel riding in the vehicle would be engaged with small arms.

AMSAA provided the probability of kill and the probability of a mobility kill for the M72 LAW and 90mm recoilless rifle against an M35 series truck moving at 20 mph. The engagement range was 150 meters. The computation of the outcome is a straight forward basic probability problem.

Let LK = Prob(kill) with a LAW  
LD = Prob(damage) with a LAW  
 $n$  = number of LAW's

Then,

$$\begin{aligned} \text{Prob(kill for } n \text{ shots)} &= 1 (1 - LK)^n \\ \text{Prob(no damage for } n \text{ shots)} &= (1 - LK - LD)^n \\ \text{Prob(damage in } n \text{ shots)} &= 1 - (\text{P(kill)} + \text{P(no damage)}) \end{aligned}$$

The computation of the results for the 90mm recoilless rifle are computed identically.

DIRECT FIRE VS. VEHICLES AND MOUNTED PERSONNEL TABLE

(Table 6)

RAIDER NUMBER	ATTACKER COMBAT STRENGTH								
	0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44
0 - 9	0/--	10/--	20/--	20/--	30/--	30/--	40/--	40/--	50/--
10 - 19	10/--	20/--	20/--	30/--	30/--	40/--	40/H	50/N	50/N
20 - 29	10/--	20/--	20/--	30/--	40/--	40/--	50/N	50/N	60/H
30 - 39	10/--	20/--	20/--	30/--	40/--	50/H	50/N	50/N	60/H
40 - 49	10/--	20/--	30/--	40/H	50/N	50/N	50/N	60/M	60/H
50 - 59	10/--	20/--	30/--	40/--	40/H	50/N	50/N	60/M	60/H
60 - 69	10/--	20/--	30/--	40/H	50/N	50/N	60/N	60/M	70/D
70 - 79	10/--	20/--	30/--	40/H	50/0	50/0	60/D	70/D	70/D
80 - 89	10/--	20/--	30/H	40/H	50/0	60/D	60/D	70/D	80/D
90 - 99	10/--	20/H	30/H	40/D	50/D	60/D	70/D	80/D	80/D

\* NUMBER = PERCENTAGE PERSONNEL CASUALTIES; --- = NO DAMAGE; "H" = MOBILITY DAMAGE; "D" = VEHICLE DESTROYED

Figure 6-1. Direct fire vs. vehicles and personnel

Since each shot (regardless of what fired it) is an independent event, the final outcome for a mix of LAW's and 90mm recoilless rifles can easily be computed.

Let LKN = Prob(kill with n LAW)  
LDN = Prob(damage with n LAW)  
RKN = Prob(kill with n 90mm)  
RDN = Prob(damage with n 90mm)

Then,

$$\begin{aligned}\text{Prob(kill)} &= 1 - ((1 - \text{LKM})(1 - \text{RKN})) \\ \text{Prob(no damage)} &= (1 - \text{LKN} - \text{LDN})(1 - \text{RKN} - \text{RDN}) \\ \text{Prob(damage)} &= 1 - (\text{Prob(kill)} + \text{Prob(no damage)})\end{aligned}$$

Once these three probabilities are computed, they are rounded to the nearest 10% (insuring they still sum to 100%). This damage distribution is then put into the table for the results against a vehicle. The draw of a uniform random number [1, 99] will determine the damage level.

Damage to personnel followed the procedure used in the generation of the personnel damage in the helicopter table. Troops were said to be riding in the bed of the truck. For an M35 series truck, the bed is 14 feet long and 4 feet high. Using the equation in chapter 5, the probability of one bullet passing through the troop compartment could be determined.

Chapter 5 made an assumption about the number of rounds to be fired; the maximum sustained rate for one minute. It was felt that a one minute exposure was too long and the exposure time was cut to one half minute. This of course cuts the number of rounds fired at the troops by 50%.

Since each round is an independent event, the expected number of bullets to pass through the troop compartment is  $n \cdot p$ . For each column (each having a certain firepower score and associate weapon mix) the expected number of rounds to pass through the troop compartment was computed and then rounded off to an integer value.

Each truck was assumed to have 10 soldiers in the truck. If a bullet passed through the troop compartment, then one troop would be hit with probability one and each troop had an equal probability (.1) of being the troop hit. If the expected number of bullets to pass through the troop compartment are regarded as  $n$  trials of an experiment, then the outcome of this condition becomes a random variable distributed against a multinomial distribution. In other words, one gets the probability of no kills, one kill, ..., ten kills. One kill corresponds to a 10% loss of the whole force, so the probabilities of losses in 10% graduations is also known.

It is now an easy process to enter the personnel losses into the table to reflect the distribution of losses for a given column against the uniform random number [1, 99] that determines the row entry.

The entries in the combat results tables reflect fractional damage to personnel in the bed of the truck. These fractional damages apply be there 0,1,2 ...n passengers in the truck. The use of fractional damages enables the elimination of many tables. To be completely correct, one table for each case of 0,1,2, ...n passengers should be generated. An analysis of the error involved in this methodology was conducted and the delta was found to be insignificant. Hence, the original assumption of 10 soldiers in the truck was required for the results table generation, but the use of the results table does not demand a full truck in the play of the game.

## Chapter 7

### Mines and Boobytraps

7.1. General. This chapter describes the generation of two different combat results tables. The first table is the results of mines and boobytraps vs personnel. The second is the results of mines vs vehicles and personnel. To use the table for mines and boobytraps vs dismounted personnel (figure 7.1), a uniform random number [1, 99] is drawn. The table is entered and a percent casualty number is returned. This table is used against a squad or smaller unit only. The use of the mines vs vehicles and mounted personnel (figure 7.2) is used identically. The difference is that the latter table provides a second bit of information, the damage level to vehicle.

7.2. Methodology, Antipersonnel. The CAORA study "Mine Warfare Analysis" provides effectiveness for U.S. Antipersonnel mines. A common U.S. mine was chosen as the representative mine/boobytrap. The mine study also provides the probability of killing the first soldier, second soldier, third soldier and fourth soldier. These probabilities were then converted into the probability of killing none, one, ..., four soldiers. The sequence of numbers [1, 99] is grouped to reflect the probabilities of killing none to four soldiers.

7.3. Methodology, Antivehicular. This table (figure 7.2) is purely subjective. No antitank mines have been provided to LATAM countries since there is no tank threat. As such, those mines are not available to either red or blue. The real world situation is a homemade pipe bomb placed in the road. In other words, the antivehicle mine threat is so nonstandard that an accurate table cannot be generated. This subjective table provides a full range of damage outcomes to account for any mine from a firecracker to a 500 pound bomb buried in the road.

MINES AND BOOBY TRAPS VS. DISMOUNTED PERSONNEL  
(Table 7)

RANDOM NUMBER	PERCENT CASUALTIES
0 - 5	0
6 - 40	10
41 - 83	20
84 - 98	30
99	40

Figure 7-1. Mines and booby traps vs. personnel

## MINES VS. VEHICLES AND MOUNTED PERSONNEL

(Table 8)

RANDOM NUMBER	VEHICLE DAMAGE	PERCENT CASUALTIES TO VEHICLE PASSENGERS
0 - 9	NO DAMAGE	0
10 - 19	NO DAMAGE	0
20 - 29	MOBILITY DAMAGE	10
30 - 39	MOBILITY DAMAGE	10
40 - 49	MOBILITY DAMAGE	20
50 - 59	MOBILITY DAMAGE	20
60 - 69	MOBILITY DAMAGE	30
70 - 79	DESTROYED	40
80 - 89	DESTROYED	50
90 - 99	DESTROYED	60

Figure 7-2. Mines vs. vehicles and personnel

## Chapter 8 Sniper Table

8.1. General. The sniper table (figure 8.1) reflects the losses inflicted by a sniper given a shot and provides the results of return fire by the attacked unit.

8.2. Methodology. The 61JTCG/ME-80-7-1 provides the effectiveness of a Soviet 7.62 sniper rifle against personnel at various ranges. Two sets of numbers are provided, the probability of hit and the probability of kill given a hit. These numbers were averaged to determine some representative number across the range spectrum. From these two average probabilities, the following can be computed.

$$\begin{aligned} \text{Prob(kill)} &= \text{Prob(hit)} \times \text{Prob(kill given hit)} \\ \text{Prob(miss)} &= 1 - \text{Prob(hit)} \\ \text{Prob(wound)} &= 1 - (\text{Prob(kill)} + \text{Prob(miss)}) \end{aligned}$$

The probability assignments were entered into the results table for the outcome of the sniper's first shot.

After a sniper shoots at a unit, personnel will move more carefully and provide a reduced target for the sniper's second shot. By examining the single shot kill probabilities for various small arms, there is roughly a 50% reduction in effectiveness against a standing and prone target. By combining these two points, the assumption made about the second shot was that the probability of hit is reduced 50%. The outcome for the sniper's second shot is then computed exactly as the first shot outlined above.

The architecture of the game allows a sniper to shoot only two times from any firing position during a game turn. Thus the table only allows for a maximum of two shots. In the case of a red sniper, the engagement location and game turn of the engagement are scripted into the red scenario before play begins. If blue is unable to kill the sniper after two shots by the sniper, the red sniper returns to his parent unit. The inventory of red snipers is not strictly maintained; the driving document is the red scenario. If a sniper is called for in the red scenario, a sniper will be available and in position. Blue on the other hand does maintain an inventory of snipers. If blue employs a sniper, then the sniper must be available, he must move to his position, shoot and return to his unit or next firing position if he has not been killed or captured. The action of the blue sniper after his two shots in any one firing position is dictated by his parent unit. The blue sniper is highly controlled by the blue force headquarters. A training task requires the control of all available assets by the blue force headquarters and snipers fall within the definition of assets.

For the effectiveness of blue return fire, a technique from DARCOM P-706-101 was employed. After the first shot by the sniper, the blue force knows that the sniper is in a vertical plane 100 feet high and 300 feet long. The average dimension of a prone soldier is 1.5 feet by 1.5 feet. If blue returns

**SNIPER TABLE**

(Table 5)

**SNIPER VS. PERSONNEL**

RANDOM NUMBER		TARGET UNIT CASUALTIES
FIRST ATTACK	0 - 7	MISS
	8 - 23	WOUND
	24 - 99	KILL
SECOND ATTACK	0 - 53	MISS
	54 - 61	WOUND
	62 - 99	KILL

**RETURN FIRE RESULTS**

RANDOM NUMBER		SNIPER CASUALTIES
FIRST ATTACK	0 - 99	MISS
	0 - 61	MISS
SECOND ATTACK	62 - 89	WOUND
	90 - 99	KILL

**Figure 8-1. Sniper Table**

fire with one round into the 100 x 300 foot plane, then

$$\text{Prob(hit sniper)} = \text{Area(sniper)}/\text{Area(plane)}$$

and if n rounds are fired into the plane uniformly, then

$$\text{Prob(hit sniper } n \text{ rounds}) = 1 - (1 - \text{Prob(hit sniper)})^n$$

It was assumed that one blue squad would return fire with 12 rounds per M16 and 10 five round bursts from the M60 for a total of 146 rounds.

After the sniper shoots a second time, the location of the sniper is refined to a plane 15 ft high by 45 ft long. The probability of the squad hitting the sniper is then computed just as above.

An assumption was made that the probability of kill given a hit was 0.25. Thus,

$$\text{Prob(miss sniper)} = 1 - \text{Prob(hit sniper)}$$

$$\text{Prob(wound sniper)} = \text{Prob(hit)} \times .75$$

$$\text{Prob(kill sniper)} = \text{Prob(hit)} \times .25$$

The miss/wound/kill results for the blue return fire was entered into the results table according to the appropriate probability distribution.

## Chapter 9 Air Defense

9.1. General. This section describes the generation of two tables; SA-7/Redeye Air Defense (figure 9.1) and Small Arms Air (figure 9.2). To use the SA-7/Redeye table, for each missile used, a uniform random number [1, 99] is drawn and the results against the target are provided by the table. To use the Small Arms Air Defense Table, a uniform random number [1, 99] is drawn and the damage determined for the size of unit making the engagement by target range and type attacking aircraft.

9.2. Methodology, SA-7/Redeye. The SA-7/Redeye Air Defense table is Redeye probability of kill data taken directly from an unclassified table in the JMEMS.

9.3. Methodology, Small Arms. The methodology used here very closely follows the methodology used to determine results of small arms fire against landing helicopters. The A-37 Dragonfly is an aircraft that was used in Vietnam and is currently in service in LATAM. As such, it became the generic fixed wing aircraft. Again, data was from the Combat Data Information Center from Vietnam results provided the probability, that given a hit by small arms, the aircraft would crash, mission abort or continue the mission without interruption. The combat data that provided this distribution is classified. The side silhouette of the A-37 is 17 square meters. The aim error for small arms was provided by AMSAA for an attack speed of 250 knots. The UH1 has an area of 20 square meters and an attack speed of 100 knots. The probability, given the helicopter was hit, that the aircraft is destroyed is 0.05, damaged 0.20 and continued the mission 0.75. The aim error was also provided by AMSAA.

The probability that at least one bullet would hit the aircraft is given by

$$\text{Prob(hit)} = 1 - \exp \frac{-nA}{A + 2 S^2}$$

where

$n$  = number of rounds fired

$A$  = area of aircraft ( $\text{m}^2$ )

$S$  = range to aircraft (km)  $\times \sigma$

$\sigma$  = aim error (mills)

If  $n$  equal one, then the single shot probability is computed. Again, since each round is an independent event, the expected number of rounds to hit the aircraft is  $np$ .

SA-7/STINGER/REDEYE AIR DEFENSE

(TABLE 2)

<u>RANGE</u>	HELICOPTER		FIXED WING	
	<u>KILL</u>	<u>MISS</u>	<u>KILL</u>	<u>MISS</u>
1000 - 4000	0-37	38-99	0-37	38-99
4001 - 7000	0	1-99	0-37	38-99

NOTE: An SA-7/Stinger/Redeye will not be fired from jungle or forest.

Figure 9-1. SA-7/Redeye air defense

## SMALL ARMS AIR DEFENSE

(Table 1)

## SMALL ARMS (SQUAD)

HELICOPTER				FIXED WING		
RANGE	MISS	DAMAGED	DESTROYED	MISS	DAMAGED	DESTROYED
0-250	0-9	10-65	66-99	0-73	74-87	88-99
251-500	0-55	56-89	90-99	0-99	---	---

## SMALL ARMS (PLATOON)

HELICOPTER				FIXED WING		
RANGE	MISS	DAMAGED	DESTROYED	MISS	DAMAGED	DESTROYED
0-250	---	0-30	31-99	0-39	40-68	68-99
251-500	0-17	18-72	73-99	0-73	74-87	88-99

## SMALL ARMS (COMPANY)

HELICOPTER				FIXED WING		
RANGE	MISS	DAMAGED	DESTROYED	MISS	DAMAGED	DESTROYED
0-250	---	0-2	3-99	0-6	7-32	33-99
251-500	0-17	0-37	73-99	0-46	47-72	73-99

Figure 9-2. Small arms air defense

An assumption was made that each M16 would fire 12 rounds and each M60 would fire 50 rounds. Then a squad would fire 146 rounds, a platoon 438 rounds and a company 1314 rounds. Most of the aircraft hit (both damaged and destroyed) in Vietnam were hit by only one round. Therefore, the conclusion was drawn that the damage distribution mentioned above was the result of one round. That is to say that the total damage from multiple hits is not additive but rather an identical experiment repeated for each bullet impact. As such, when the expected number of rounds was computed, that number of draws was made against the appropriate damage data from Vietnam.

Let  $E(n)$  = expected hits on an aircraft

$P_k$  = Prob(kill given a hit)

$P_D$  = Prob(damage given a hit)

$P_N$  = Prob(no damage given a hit)

Then

$$\text{Prob(kill)} = 1 - (1 - P_k)^{E(n)}$$

$$\text{Prob(no damage)} = P_N^{E(n)}$$

$$\text{Prob(damage)} = 1 - (\text{Prob(kill)} + \text{Prob(no damage)})$$

These probabilities became the table entries by grouping the sequence of numbers [1, 99] into blocks representing no damage, damage and kill outcomes.

## Chapter 10 Indirect Fire Support

10.1. General. This chapter describes the generation of ten indirect fire tables. The first table (figure 10.1) assigns a firepower score to each type of indirect fire projectile. The remaining nine tables (figures 10.2 thru 10.9) assign an outcome against a squad, platoon or company target depending on whether the target is in the open, in wooded terrain, or in an urban area. To use the tables, the indirect firepower score is determined by multiplying the firepower score for the type round fired by the number of rounds fired. Next the appropriate results table is chosen. This is done depending on the unit size of the target and the target's disposition. The indirect firepower designates a row in the table. Next a uniform random number [1, 99] is drawn to identify the table column. The ij entry identified by the selected row and column is the percent damage inflicted on the target unit.

10.2. Methodology. The QUICKIE model was the primary analytical tool used to generate all ten tables in this chapter. To generate the indirect firepower score, the 60mm, 81mm and 120mm mortars and the 75mm and 105mm howitzer each fired 20 rounds against each of the three targets in each of the three postures. The input data for the QUICKIE model is the lethal area for each type round, the pattern size for a volley and the ballistic and aim error for each of the systems. All this data were provided by AMSAA. One assumption made was that each system fired at the nine targets at a range equal to one half of the system's maximum range.

The damage that was inflicted by each type system against the three unit targets in the three postures was then averaged. At this point, each system has an average level of damage. These averages were then normalized to the 75mm howitzer. The values in the Indirect Fire Strength table are then normalized outcomes rounded to the nearest one half point. The least effective system was the 75mm howitzer and it became the base weapon with a value of 1. Table 2 shows the values of the other types of ammunition resulting from this process.

Again, the table format required that five outcomes columns for each associated firepower score be provided in each table. The outcomes were achieved by varying the size of the area that a unit occupied. The assumption was made that 20% of the time the unit would be very dispersed; 60% of the time the unit would occupy an area along doctrinal lines; and 20% of the time, the unit would be grouped tighter than tactically sound. These percentages are captioned in the five columns on the results table where the uniform random number [1, 99] is used to determine the column used.

The actual table entries were then obtained from the QUICKIE model by firing the 75mm howitzer at the unit in each of the three densities. The number of rounds fired equalled the indirect firepower score (since the 75mm round had a value of one point). The percent losses were then entered into the table. The losses were all rounded to 10% increments; again a format constraint of ABSALON.

INDIRECT FIRE STRENGTH (IFS)

TABLE 2

<u>TYPE WEAPONS</u>	<u>INDIRECT FIRE STRENGTH</u>
*75 MM Pack Howitzer	1/Round
60 MM Mortar	1.5/Round
105 MM Howitzer	1.5/Round
81 MM Mortar	3/Round
120 MM Mortar	3.5/Round
*Threat only	

Figure 10-1. Indirect fire strength

## DAMAGE ASSESSMENT

(SQUAD IN OPEN)

TABLE 3

<u>INDIRECT FIRE STRENGTH</u>	<u>RANDOM NUMBERS</u>				
	<u>0-20</u>	<u>21-40</u>	<u>41-60</u>	<u>61-80</u>	<u>81-90</u>
0-6	0	0	0	0	10
7-12	0	0	0	0	10
13-24	10	10	10	10	10
25-36	10	10	10	20	20
37-48	10	20	20	20	20
49-60	20	20	20	20	20
61-72	20	30	30	30	30
73-84	30	30	30	30	30
85-96	30	30	30	30	30
97-108	30	30	30	30	30

Figure 10-2. Artillery damage, squad in open

DAMAGE ASSESSMENT  
(SQUAD IN FOREST/JUNGLE)

TABLE 4

INDIRECT FIRE STRENGTH	RANDOM NUMBERS				
	0-20	21-40	41-60	61-80	81-90
0-6	0	0	0	0	0
7-12	0	0	0	0	10
13-24	0	0	0	10	10
25-36	0	10	10	10	10
37-48	10	10	10	10	10
49-60	10	10	10	10	20
61-72	10	10	10	20	20
73-84	20	20	20	20	20
85-96	20	20	20	20	30
97-108	20	20	20	30	30

Figure 10-3. Artillery damage, squad in jungle

## DAMAGE ASSESSMENT

(SQUAD IN URBAN)

TABLE 5

<u>INDIRECT FIRE STRENGTH</u>	<u>RANDOM NUMBERS</u>				
	<u>0-20</u>	<u>21-40</u>	<u>41-60</u>	<u>61-80</u>	<u>81-90</u>
0-6	0	0	0	0	10
7-12	0	0	0	10	10
13-24	0	0	10	10	10
25-36	0	10	10	10	10
37-48	10	10	10	10	10
49-60	10	10	10	10	10
61-72	10	10	10	10	20
73-84	10	10	10	20	20
85-96	10	10	20	20	20
97-108	10	20	20	20	20

Figure 10-4. Artillery damage, squad in urban

DAMAGE ASSESSMENT  
(PLATOON IN OPEN)

TABLE 6

INDIRECT FIRE STRENGTH	RANDOM NUMBERS				
	0-20	21-40	41-60	61-80	81-90
0-6	0	0	0	0	0
7-12	0	0	0	10	10
13-24	0	10	10	10	10
25-36	0	10	10	10	10
37-48	10	10	10	10	10
49-60	10	10	10	10	20
61-72	10	10	10	20	20
73-84	20	20	20	20	20
85-96	20	20	20	20	20
97-108	20	20	20	30	30

Figure 10-5. Artillery damage, platoon in open

DAMAGE ASSESSMENT  
(PLATOON IN FOREST/JUNGLE)

TABLE 7

INDIRECT FIRE STRENGTH R/N	RANDOM NUMBERS				
	0-20	21-40	41-60	61-80	81-90
0-6	0	0	0	0	0
7-12	0	0	0	0	10
13-24	0	0	0	10	10
25-36	0	10	10	10	10
37-48	10	10	10	10	10
49-60	10	10	10	10	10
61-72	10	10	10	10	20
73-84	10	10	10	20	20
85-96	10	10	20	20	20
97-108	10	20	20	20	20

Figure 10-6. Artillery damage, platoon in jungle

DAMAGE ASSESSMENT  
(PLATOON IN URBAN)

TABLE 8

INDIRECT FIRE STRENGTH R/N	RANDOM NUMBERS				
	0-20	21-40	41-60	61-80	81-90
0-6	0	0	0	0	10
7-12	0	0	0	10	10
13-24	0	0	10	10	10
25-36	0	10	10	10	10
37-48	10	10	10	10	10
49-60	10	10	10	10	20
61-72	10	10	10	20	20
73-84	10	10	20	20	20
85-96	10	20	20	20	20
97-108	20	20	20	20	20

Figure 10-7. Artillery damage, platoon in urban

## DAMAGE ASSESSMENT

(COMPANY IN OPEN)

TABLE 9

INDIRECT FIRE STRENGTH	RANDOM NUMBERS				
	0-20	21-40	41-60	61-80	81-90
0-6	0	0	0	0	0
7-12	0	0	0	0	10
13-24	0	0	0	0	10
25-36	0	0	0	10	10
37-48	0	0	10	10	10
49-60	0	0	10	10	10
61-72	0	10	10	10	20
73-84	10	10	10	20	20
85-96	10	10	10	20	20
97-108	10	10	10	20	20

Figure 10-8. Artillery damage, company in open

DAMAGE ASSESSMENT  
(COMPANY IN FOREST/JUNGLE)

TABLE 10

INDIRECT FIRE STRENGTH	RANDOM NUMBERS				
	0-20	21-40	41-60	61-80	81-90
0-6	0	0	0	0	10
7-12	0	0	0	0	10
13-24	0	0	0	0	10
25-36	0	0	0	10	10
37-38	0	0	0	10	10
49-60	0	0	10	10	10
61-72	0	10	10	10	10
73-84	10	10	10	10	10
85-96	10	10	10	10	10
97-108	10	10	10	10	20

Figure 10-9. Artillery damage, company in jungle

## DAMAGE ASSESSMENT

(COMPANY IN URBAN)

TABLE 11

<u>INDIRECT FIRE STRENGTH</u>	<u>RANDOM NUMBERS</u>				
	<u>0-20</u>	<u>21-40</u>	<u>41-60</u>	<u>61-80</u>	<u>81-90</u>
0-6	0	0	0	0	0
7-12	0	0	0	0	10
13-24	0	0	0	10	10
25-36	0	0	0	10	10
37-48	0	0	10	10	10
49-60	0	0	10	10	10
61-72	0	10	10	10	10
73-84	10	10	10	10	10
85-96	10	10	10	10	20
97-108	10	10	10	20	20

Figure 10-10. Artillery damage, company in urban

## Chapter 11 Air to Ground Table

11.1. General. These tables are used to determine damage inflicted on units by either rotary or fixed wing aircraft. There are three tables (figure 11.1 thru 11.3), each table corresponding to a squad, platoon or company target. To use the table, a uniform random number [1, 99] is drawn to identify the column. Next, the row corresponding to the number of aircraft and type ordnance is selected. The ij entry designated by the selected row and column provides the percent damage inflicted on the target.

11.2. Methodology. Since this was an all purpose set of tables, performance of the 7.62 mini gun, the 20mm cannon and 68mm (2.75 in) rockets against the three unit size targets was taken directly from JMENS data for helicopter deliveries. Data for general purpose bombs and cluster munitions was also taken from JMENS for visual deliveries from a high performance aircraft. Jane's "All the World Aircraft" was the source document for a representative ordnance load on an AH1-G and an A37. Delivery angles, target ranges, attack speeds, delivery errors, methods of release were all assumed to be the median values available in the JMENS tables. When a damage value was taken from JMENS, it was for one aircraft. The damage for multiple aircraft was then probabilistically combined as follows:

Let  $D_1$  = (percent Damage for one aircraft)/100

Then

$$D_X = \text{Percent Damage for } X \text{ aircraft}$$

$$D_X = (1 - (1 - D_1)^X) \times 100$$

The damage for one through four aircraft against each size target was computed. These values were then rounded to the nearest 10% damage; again, a format requirement from the original ABSALON document.

JMEMS provides an expected value for damage. To provide some variability in damage outcome for the game, the following assumptions were adopted. The JMEMS values computed above were assumed to occur 60% of the time and as such, became the table entries for the middle three columns of each table. The assumption was then made that at 20% of the time, the damage would be 10% greater and 20% of the time the damage would be 10% less than the expected damage. This assumption provided the numbers that became the first and fifth column in each of the three tables.

## AIR-TO-GROUND

TABLE 4

## SQUAD SIZED TARGETS

<u>ORDNANCE</u>	# OF AIRCRAFT	RANDOM NUMBER				
		0-20	21-40	41-60	61-80	81-99
Cluster Bombs	1	40	50	50	50	60
	2	60	70	70	70	80
	3	80	80	80	90	90
	4	80	90	90	90	100
General Purpose Bombs	1	10	20	20	20	30
	2	20	30	30	40	40
	3	40	50	50	50	60
	4	50	60	60	60	70
7.62 MM mini gun	1	20	30	30	30	40
	2	40	50	50	50	60
	3	60	60	60	70	70
	4	70	70	70	80	80
68 MM Rockets	1	90	90	90	100	100
	2	90	100	100	100	100
	3	90	100	100	100	100
	4	100	100	100	100	100
20 MM Cannon	1	100	100	100	100	100
	2	100	100	100	100	100
	3	100	100	100	100	100
	4	100	100	100	100	100

Figure 11-1. Air-to-ground, squad target

AIR-TO-GROUND  
PLATOON SIZED TARGETS  
(TABLE 5)

ORDNANCE	# OF AIRCRAFT	RANDOM NUMBER				
		0-20	21-40	41-60	61-80	81-99
Cluster Bombs	1	40	50	50	50	60
	2	60	70	70	70	80
	3	80	80	80	90	90
	4	80	90	90	90	100
General Purpose Bombs	1	10	10	10	20	20
	2	20	30	30	30	40
	3	30	40	40	40	50
	4	40	50	50	50	60
7.62 MM mini gun	1	10	10	10	20	20
	2	20	20	20	30	30
	3	30	30	40	40	40
	4	40	40	40	50	50
68 MM Rackets	1	50	60	60	60	70
	2	70	80	80	80	90
	3	80	90	90	90	100
	4	90	100	100	100	100
20 MM Cannon	1	80	90	90	90	100
	2	100	100	100	100	100
	3	100	100	100	100	100
	4	100	100	100	100	100

Figure 11-2. Air-to-ground, platoon target

AIR-TO-GROUND  
COMPANY SIZED TARGETS

(TABLE 6)

ORDNANCE	# OF AIRCRAFT	RANDOM NUMBER			
		0-20	21-40	41-60	61-80
Cluster Bombs	1	40	50	50	50
	2	60	70	70	70
	3	80	80	80	90
	4	80	90	90	100
General Purpose Bombs	1	0	10	10	20
	2	10	20	20	30
	3	20	30	30	40
	4	30	40	40	50
7.62 MM mini gun	1	0	0	0	10
	2	0	10	10	20
	3	10	20	20	30
	4	10	20	20	30
68 MM Rockets	1	30	30	30	40
	2	50	60	60	70
	3	60	70	70	80
	4	70	80	80	90
20 MM Cannon	1	50	60	60	70
	2	80	80	80	90
	3	90	90	90	100
	4	90	100	100	100

Figure 11-3. Air-to-ground, company target

## Chapter 12

### Air-to-Air Results

12.1. General. Figure 12.1 is the table that provides loss data for air to air combat. To use the table, enter into the row reflecting the number of blue aircraft and the column reflecting the number of red aircraft. Two possible outcomes (2 sets of blue/red losses) are provided for each blue/red combination. Select a uniform random number [1, 99] and this will designate which of the two outcomes is used.

12.2. Methodology. Aerial results are based upon Lanchester attrition methodology. Lanchester results apply to aerial combat. As such the methodology and simulation employed in the generation of the ground combat results table was used here. The assumption made was that red and blue aircraft are equally effective. Since the simulation in Chapter 2 is time independent, then an arbitrary kill rate can be chosen for a single aircraft and it applies to all aircraft, both red and blue.

The simulation for each blue/red combination was run and two representative outcomes were selected for entry into the outcome table.

## AIR-TO-AIR COMBAT

(TABLE 3)

NUMBER OF FRIENDLY AIRCRAFT	NUMBER OF THREAT AIRCRAFT							
	2		3		4			
	0-49	50-99	0-49	50-99	0-49	50-99	0-49	50-99
1	1/0	0/1	1/0	1/1	0/1	0/1	0/1	0/1
2	0/1	1/1	1/2	2/1	2/0	1/1	1/0	2/1
3	0/1	0/1	1/1	1/2	3/2	2/3	3/2	2/2
4	0/1	0/1	0/1	1/2	2/2	2/3	2/2	3/3

(FRIENDLY LOSSES / THREAT LOSSES)

Figure 12-1. Air-to-air combat

**DISTRIBUTION:**

Defense Technical Information Center  
ATTN: DTIC-TCA  
Cameron Station, VA 22314

USACAORA  
Technical Information Services  
Room 134, Sherman Hall  
Fort Leavenworth, KS 66027-5200

CINC  
United States Southern Command  
ATTN: SCJ-3 Training  
Quarry Heights, Canal Zone  
APO Miami 34003

Commandant  
US Army Infantry School  
ATTN: ATSH-I-V-S-D  
Fort Benning, GA 31905-5593

Commander  
USA FORSCOM  
ATTN: AFDS-TAD  
Fort McPherson, GA 30330

Commander  
193d Infantry Brigade  
ATTN: ATFZU-DPT-EX  
Fort Clayton, PN  
APO Miami 34004

Commander  
USA FORSCOM  
ATTN: AFOP-TSA  
Fort McPherson, GA 30330

PM TRADE  
ATTN: AMCPM-TND-EP  
Naval Training Center  
Orlando, FL 32813

Commander  
USA TRADOC  
ATTN: ATTG-DC  
Fort Monroe, VA 23651-5000

Director  
TRASANA  
ATTN: ATOR-T  
White Sands Missile Range, NM 88002

Commander  
USA TRADOC  
ATTN: ATCD-ET  
Fort Monroe, VA 23651-5000

Commander  
Army Training Support Center  
ATTN: ATIC-DMD  
Fort Eustis, VA 23604-5166

✓ Commander  
Combined Arms Center  
ATTN: ATZL-SWS-L  
Fort Leavenworth, KS 66027-5300

Commander  
Combined Arms Center  
ATTN: ATZL-TAI  
Fort Leavenworth, KS 66027-5300

Commandant  
USAJFK-JWC  
ATTN: ODCSOPS-Training  
Fort Bragg, NC 28307

E

V

D

F I L M E D

6-86

D T I C